RESEARCH HIGHLIGHT

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Dawson E/9 Northern Sustainable House Energy Performance Assessment

INTRODUCTION

To support culturally appropriate, energy-efficient, sustainable housing design in the North, Canada Mortgage and Housing Corporation (CMHC) has worked with northern housing providers to conceptualize, design, build and monitor innovative housing projects in each of the three territories. Through this initiative, the Dawson E/9 Northern Sustainable House (NSH) was designed and built by the Tr'ondëk Hwëch'in Han Nation (THHN), with support from Yukon Housing Corporation (YHC). The design goal for this house set by the Tr'ondëk Hwëch'in was to use one ninth of the energy (89% less energy) compared with a similar house modelled to the Model National Energy Code for Houses (MNECH) (National Research Council of Canada, 1997).

The single-storey Dawson E/9 NSH duplex (see figure 1) consists of a 140-m^2 (1,500-sq.-ft.), three-bedroom unit that features solar hot water and a 120-m^2 (1,300-sq.-ft.), two-bedroom unit that features FlexHousing™ practices.[1] The E/9 NSH 'solar' unit has a two-panel solar domestic hot water system that offsets approximately 1,200 kWh of electricity that would have otherwise been required for water heating. The 'Flex' unit includes a covered deck that can easily be converted into additional rooms or storage in the future as household needs change.

Both dwellings have high levels of insulation with nominal RSI-7.8 (R-44) floor, RSI-8.4 (R-48) walls and RSI-14.1 (R-80) roof, airtight construction, electric baseboard space heating and heat recovery ventilators.[2]

Figure 1 Photo of Dawson E/9 NSH duplex – 'solar' unit left, 'Flex' unit right

[1] More information on FlexHousing™ can be found on the CMHC website http://www.cmhc-schl.ca/flex/en/index.cfm.

[2] More information on the E/9 NSH project can be found in the Research Highlight *Design and Construction of the Northern Sustainable E/9 Houses* available on the CMHC website www.cmhc.ca.

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METHODOLOGY

Billing data was utilized to determine the performance of the constructed E/9 NSH unit compared with a similar house modelled to the 1997 MNECH to see if it achieved its intended energy consumption performance objectives.

Each unit has two electrical meters, one for space heating and one for all other electrical loads (for example, lighting, domestic hot water, appliances etc.).

Space heating data from one electrical meter was available from November 2009 to October 2013. It was normalized to the average number of degree-days for Dawson, to account for annual variations in average outdoor temperatures. Daily temperature data for Dawson were used to compile 10-year average degree-days (2003 to 2013) and these averages were then used to prepare the normalized yearly electricity consumption. Electrical data for domestic hot water, lights, appliances and plug loads from the second electrical meter was available from February 2011 to November 2013 and was averaged for a 2-year period (July 2011 to July 2013).

The energy use of the E/9 units was also compared to the original design targets and the as-built targets as estimated by Natural Resources Canada's HOT2000 residential energy consumption simulation software. An as-built HOT2000 model for the E/9 NSH 'solar' and 'Flex' units was developed after the house was built, which used the same base assumptions from the original plan but accommodated for any modifications made during construction that deviated from the original plan. The electricity required for domestic hot water is the net electricity required for water heating after the contribution from the solar panels.

The simulation results are based on built-in assumptions in HOT2000, at an average load of two adults and two children at 50% occupancy. Typical assumptions include a hot water requirement of 225 L/day per unit, average electric appliances at 17 kWh/day and lighting at 3 kWh/day, as well as 4 kWh/day of average exterior electricity use. Actual occupancy for the E/9 NSH 'solar' unit is 1 adult and 1 child, both at approximately 50% occupancy.

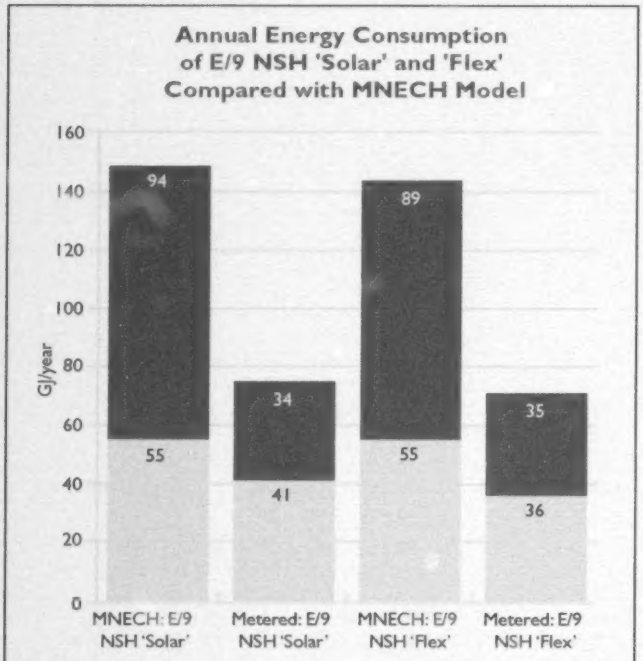
A further comparison was conducted comparing the energy consumption to a similar neighbouring project that is constructed to approach NRCan's R-2000 Standard level of performance and is considered conventional construction for this time in the neighbourhood. An EGH rating shows a standard measure of a home's energy performance on a scale of 0 to 100, calculated based on standard operation assumptions (Natural Resources Canada, 2011). An R-2000 home is considered equivalent to approximately an EGH 80 rating.

FINDINGS

Based on as-built HOT2000 modelling, the E/9 NSH units would achieve EnerGuide ratings of 85 and 86, compared with the conventional house which would achieve an approximate EGH rating of 80. A house modelled to the 1997 MNECH would achieve an EGH rating of 73 and 75. Based on billing data, the E/9 NSH units used 50% less energy overall compared with a similar unit modelled to MNECH (see figure 2). The 'solar' unit consumed 64% less energy for space heating and 25% less energy for other electrical loads (domestic hot water, lights, appliances, etc.) while the 'Flex' consumed 61% less energy for space heating and 35% less energy for other electrical loads.

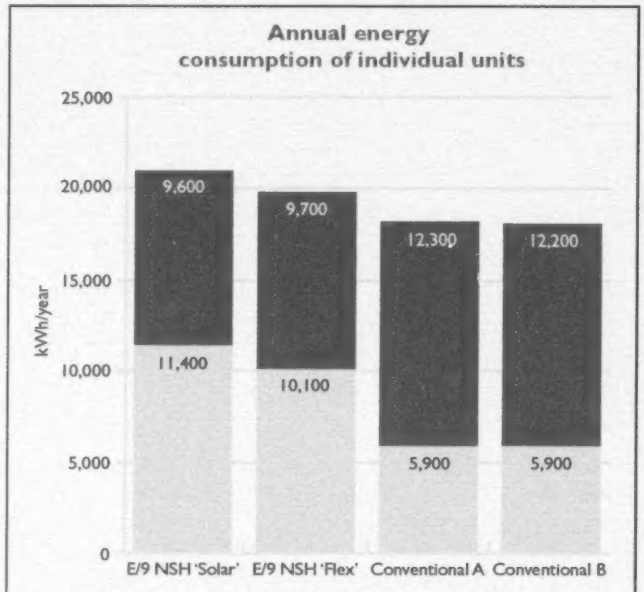
The E/9 NSH units consumed more energy overall compared with the conventional duplex; however, they used approximately 22% less energy for space heating purposes. Other electrical loads played a role in overall energy consumption—accounting for 51-54% of overall energy use in the NSH units as compared to 32% for the conventional units. Based on information taken from the occupant interviews, it appeared that the conventional units had less daily electricity consuming activity than the E/9 NSH units, which may account for the reduced electricity use for domestic hot water, lights, appliances and plug loads.

The overall actual energy consumption of the E/9 NSH 'solar' unit was within 5% of the HOT2000 as-built predicted consumption (see figure 3). However, the E/9 NSH space heating use (based on utility invoices) was 40% higher than modelled results while the electricity for electrical load (based on utility invoices) was 13% less than modelled results. Discrepancies observed between the modelled and actual consumption of E/9 NSH may be attributable—in part—to default assumptions within the model. The number of occupants, internal gains, electrical base loads, occupant schedules, the modelling of thermal



GJ/year	MNECH: E/9 NSH 'Solar'	Metered: E/9 NSH 'Solar'	MNECH: E/9 NSH 'Flex'	Metered: E/9 NSH 'Flex'
Total	149	75	144	71
■ Space heating (metered data normalized for weather)	94	34	89	35
DHW, lights, appliances, plug loads (metered data averaged)	55	41	55	36

Figure 2 Actual energy consumption of E/9 NSH 'solar' and 'Flex' units compared with MNECH model



GJ/year	E/9 NSH 'Solar'	E/9 NSH 'Flex'	Conventional A	Conventional B
Total	21,000 kWh	19,800 kWh	18,200 kWh	18,100 kWh
■ Space heating (normalized for weather)	9,600 kWh	9,700 kWh	12,300 kWh	12,200 kWh
DHW, lights, appliances, plug loads (averaged)	11,400 kWh	10,100 kWh	5,900 kWh	5,900 kWh

Figure 3 Comparison of annual energy consumption for the E/9 NSH and the conventional units

insulation values and thermal bridging effects, differences in weather conditions, and the large influence of occupant behaviour on a house can all explain the discrepancies between the modelled results and the actual billed results.

IMPLICATIONS FOR THE NORTHERN HOUSING INDUSTRY

While the E/9 NSH did not achieve a 90% reduction in energy consumption relative to its 1997 MNECH baseline, the energy efficiency measures implemented contributed to a significant reduction in space heating consumption as compared to the 1997 MNECH baseline and the neighbouring conventional units. As electrical loads are greatly affected by occupant behaviour, they are far less predictable at the design stage and, as shown by the results of this study, can have a significant impact on the actual household energy use.

Although the E/9 NSH did not meet its initial design goal, it raised the bar in terms of efficient housing in the North and there were many valuable lessons not only for the housing providers but also the maintainers, and the construction industry learned from its design, construction and monitoring phases.

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Housing Research at CMHC

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